Cognitive System Engineering Tools

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Cognitive System Engineering Tools

- Change of Approach:
  - **From: Functional optimization among human and system elements**
  - **To: Functional coordination with flexible function assignment and coordinative structures in support**
  - **From: Changing a single component has no other effect on the system.**
  - **To: Change in a single component always has other effects.**

Automation Subtext

- **Safety and Capacity of airspace operations is at some level limited by the cognitive, perceptual, or attentive characteristics of the managers, controllers, operators in that airspace.**
- **Technical aiding systems (&/or procedures) can be designed to assist the human operators and offset the limitation(s)**
- **System Safety and integrity is dependent on the appropriate awareness of operators and agents in that system, that awareness can be provided by appropriate presentation of information**

Doesn't impose other constraints limit

Only alter the limitation & otherwise don't change the airspace operation,

Enhancement will not be exploited to reach a new level of human constraint ,

Can revert to safe operations in case of all foreseeable failure modes

TOOLKIT Approach

- **We know a great deal about human-automation integration with respect to the aforementioned questions. How do we use it?**
  - Make it accessible (e.g. data repository and knowledge base development tools).
- **Some questions require focused answers. How to provide them?**
  - Develop a human human-system micro-model set for point simulation (e.g. Does auto handoff relieve controller workload? How much per a/c? Does T-Safe manage controller workload?)
- **All system changes have propagated effect. How to assess?**
  - Questionnaire for Cognitive System Engineering impact. (e.g NRS changes as overlay to current waypoint process– experimental focus on seams, ambiguity, etc.)

Analytic Processes for Human Performance in Next Generation Initiatives

- **Challenges In Performance**
  - Allocation of work in Distribution of Roles and Responsibilities among ground, air, human and automated systems
  - Communication & Information requirements to maintain appropriately tailored situation awareness to maximize safe and effective operation
  - Airspace policies procedures and operations for trajectory based operations and strategic layered intervention
  - Safety and risk assessment in complex, coupled and dynamic systems in which risk propagation paths and parameters migrate on a complex conditional basis
- **Challenge Evaluation**
  - Identification of source of impact on performance
  - Shaping that impact to meet program goals and monitoring that migration
  - Distinction among causal model's in joint cognitive systems of human-automation-organization and environment.
  - Focus of empirical and analytic resources on diagnostic and high payoff information: diamond cutting

Sources For Tools: Areas of Prior Research

- **Elementary Information Processing Functions**
  - Discrete, Non-propagated behaviors
  - Scaleable Responses: no significant interactions with scale
  - Performance Shaping Factors and their effect on EIPs

- **Human Sampling Decision & Control Behavior**
  - Visual Search and Information Acquisition (SA)
  - Discrete and Continuous Control Strategies
  - Strategic Behavior Management

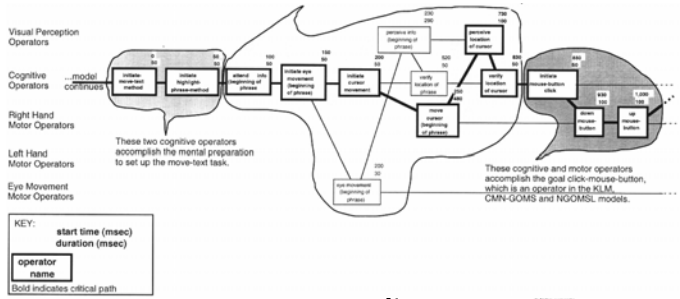
Sources For Tools

- **Human Automation Interaction**
  - Automation Lack of Feedback
  - Unidentified interrelations, side effects
  - Automation Bias
  - System Authority, Autonomy, Trust and Agent's Role
  - Fail-Safe & Reversion Processes

- **Human-System Error Trends & Risk Assessment**
  - Precursor Assessment
  - Error Identification & Prediction
  - Propagation
  - Risk Determination

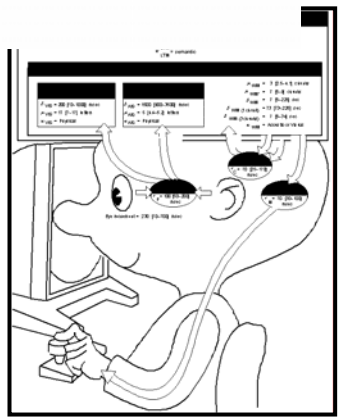
Elementary Information Processes

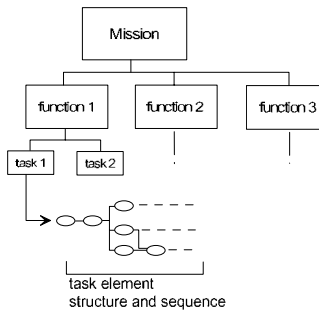
- **Critical Path Method (Cognitive, Perceptual, Motor) GOMS Analyses**



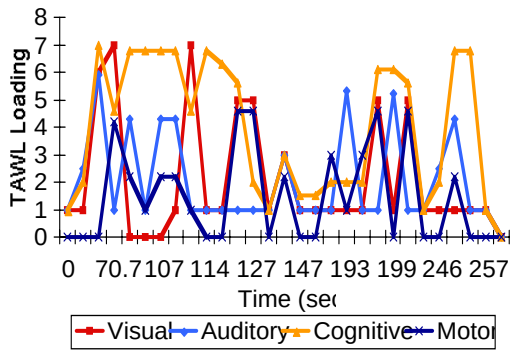
- **Model Human Processor Characteristics**
  - Three Interactive Systems
  - Each with mnenenic, attentive, processing

    and response characteristics



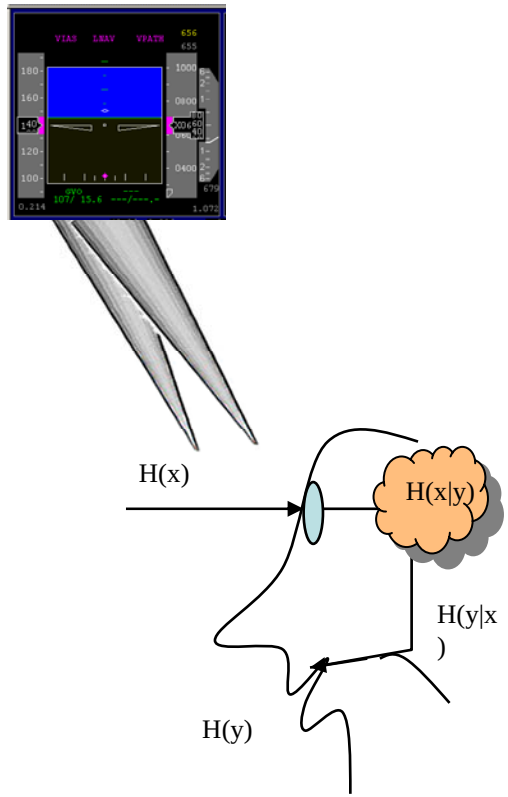


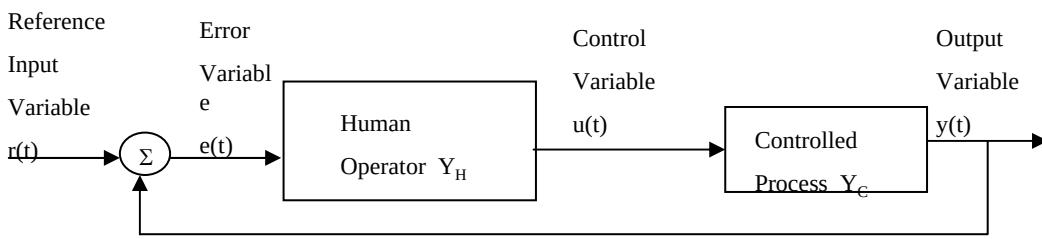
- **Performance Shaping Factors**
  - Simulation Impact
  - Contribution to Risk



Human Sampling Decision & Control Behavior

- **Visual Search & Sampling Models**
  - FAA WJHTC Data Sets
  - Lindsay Controller Model
  - Flight Deck Visual Search
- **Decision Making**
  - Naturalistic Decision Making
  - Controller/Pilot Management Strategy
  - Belief-Net Modeling
- **Discrete & Continuous Control Models**
  - Optimal Control
  - Hybrid Control
  - Context-sensitive Control





Where:

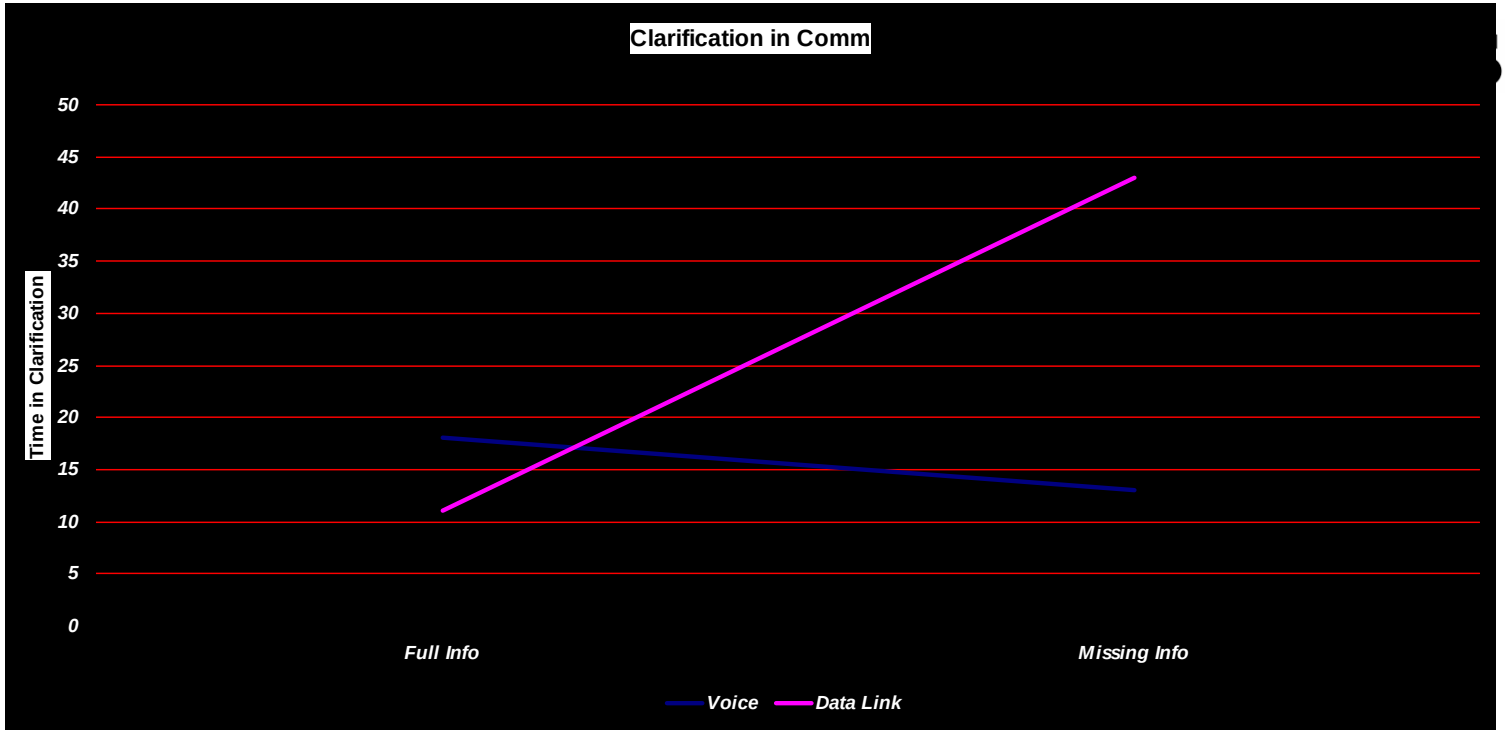
Y_H and Y_c are dynamic operators on time replaceable by Fourier transformed time functions

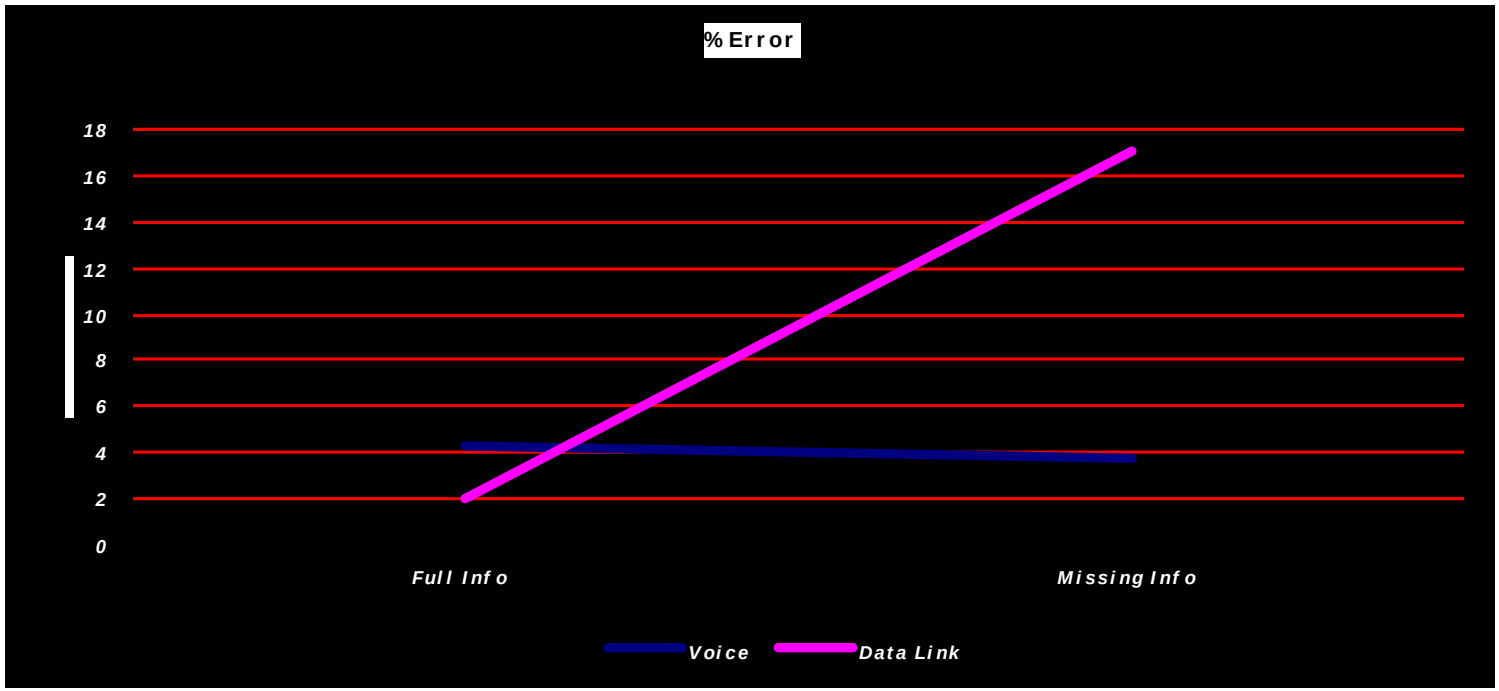
Human Automation Interaction

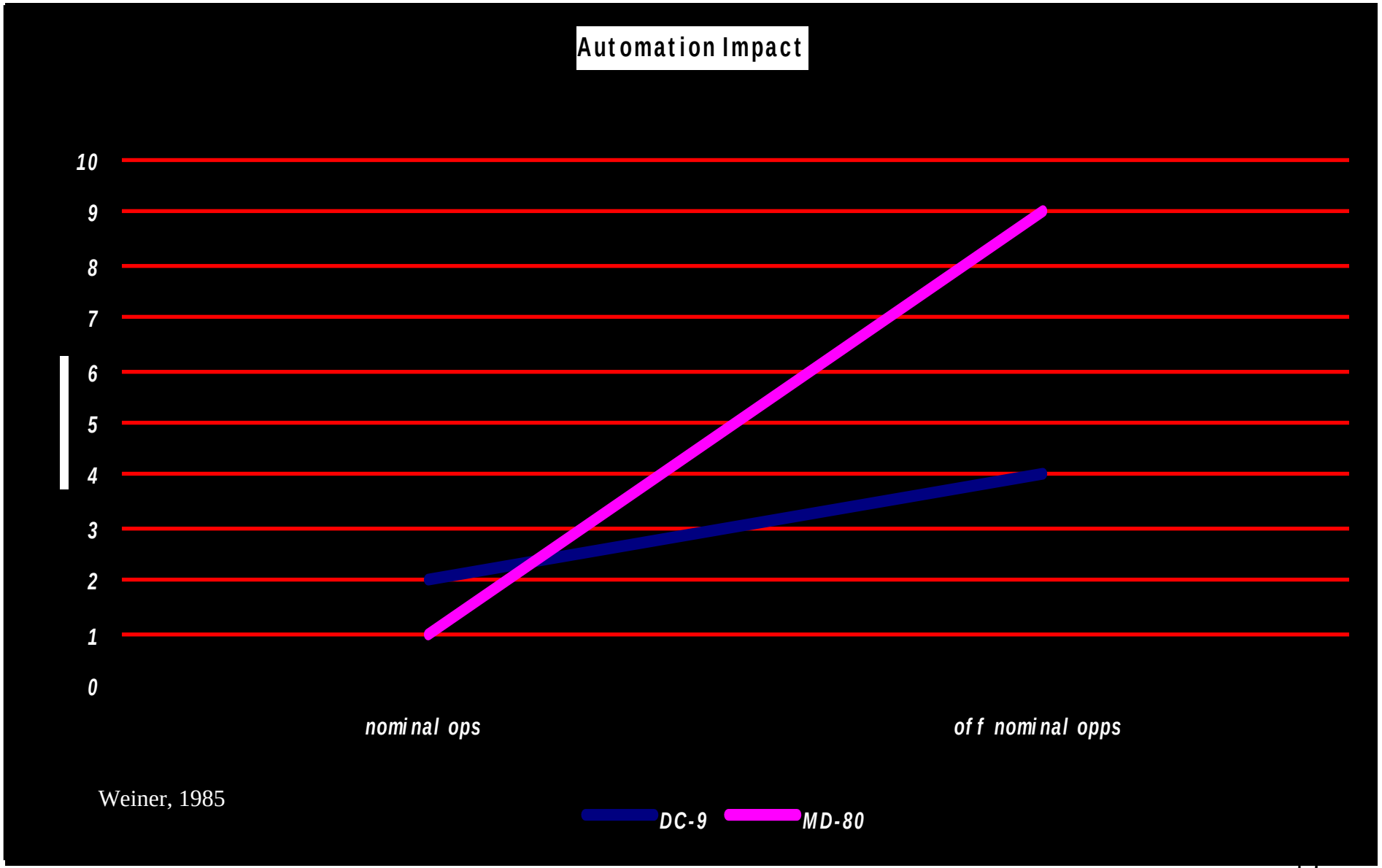
- Automation Lack of Feedback
- Workload & Error Redistribution
- Unidentified interrelations & side effects
- Automation Bias, Over-reliance, Monitoring Errors
- System Authority, Autonomy, Trust and Agent's Role
- System Alerting & Operator Double-Bind
- Situation Awareness & Fail-Safe & Reversion Processes

Voice & Data Link Communications Comparison

Lozito et al. 1999






Automation Impact
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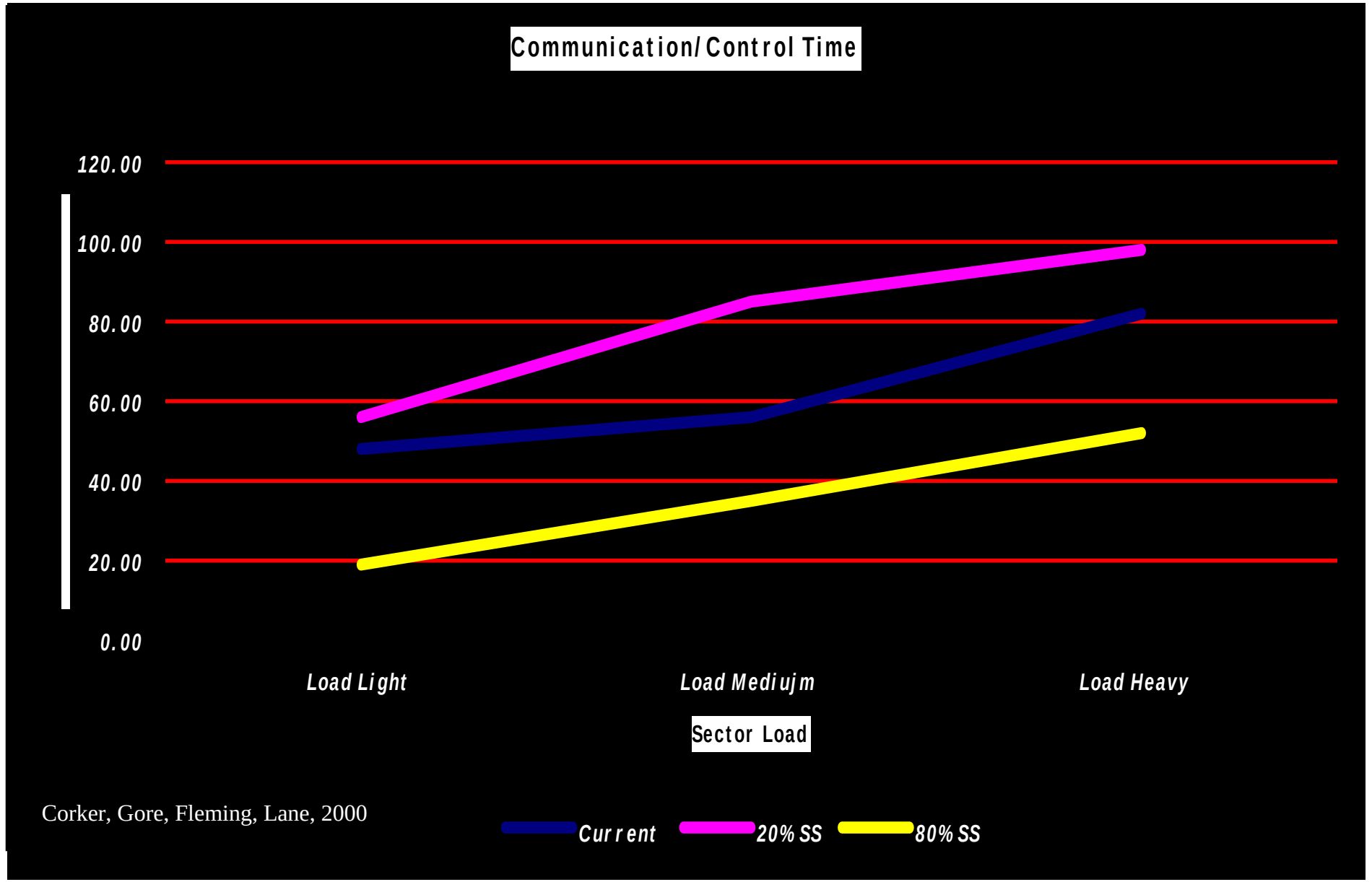
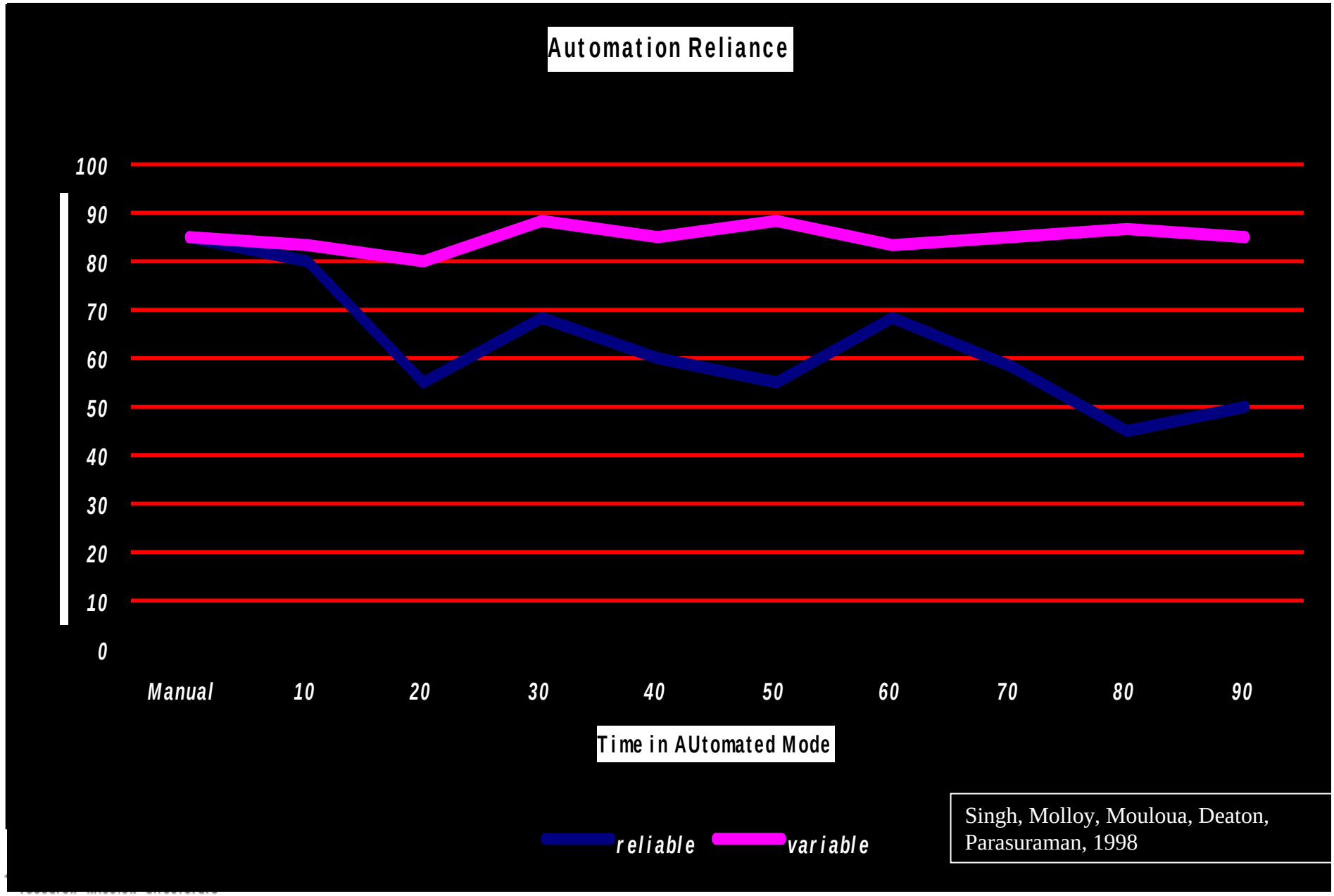
DC-9
MD-80

Weiner, 1985

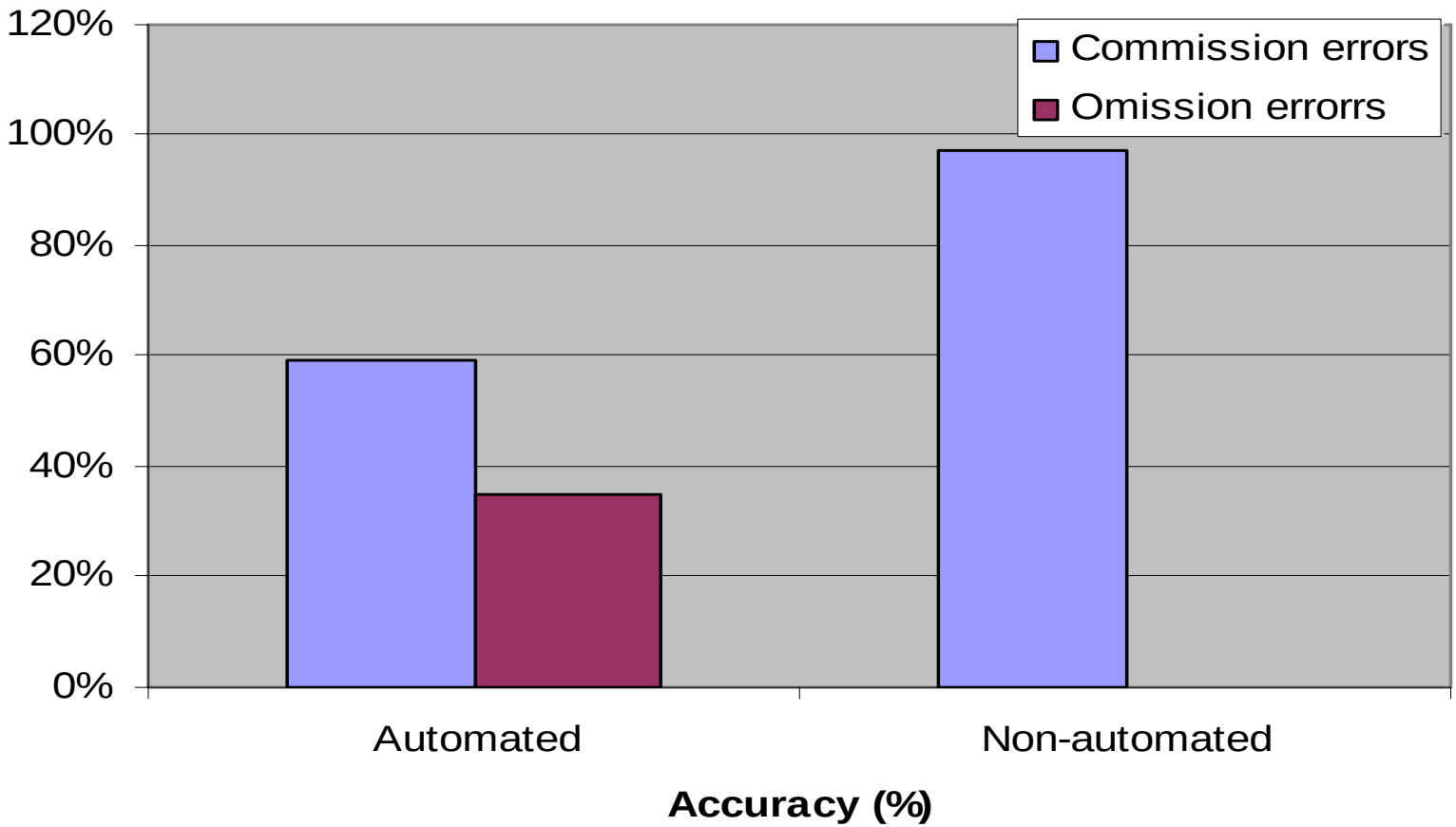


Corker, Gore, Fleming, Lane, 2000

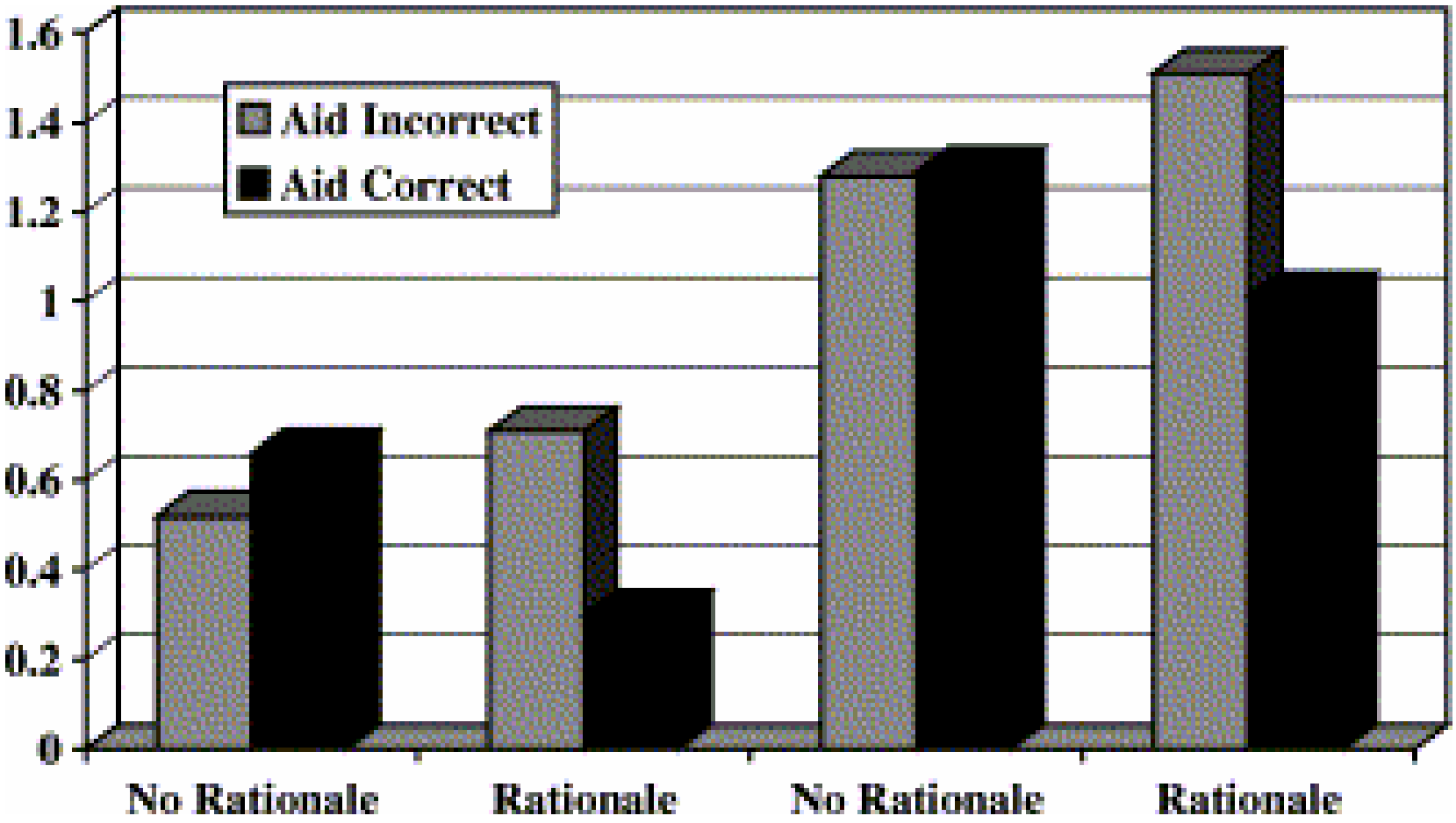


Singh, Molloy, Mouloua, Deaton, Parasuraman, 1998

Commission and Omission errros in an automated versus non-automated conditions



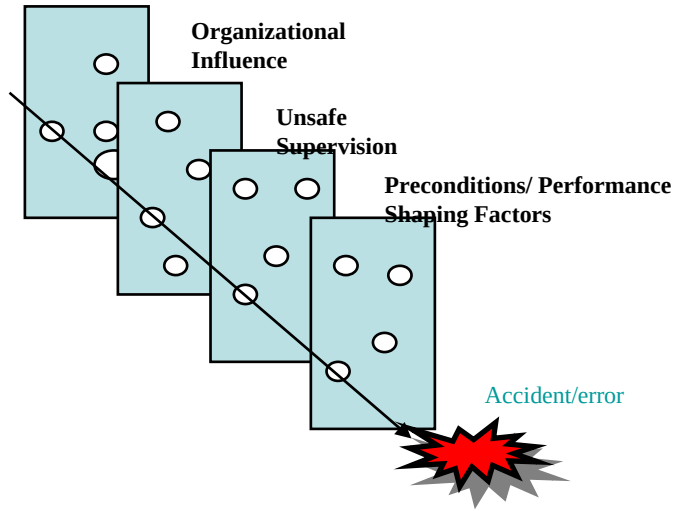
Skitka, Mosier & Burdick, 1999

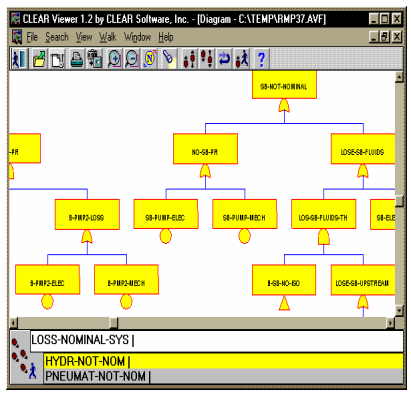


Dzindolet, Peterson, Pomranky, Pierce, and Beck (2003)

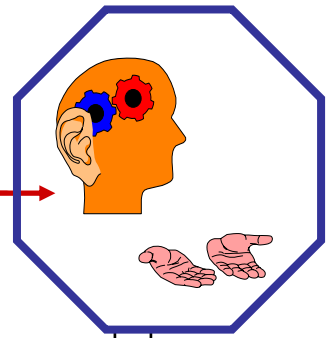
Human-System Error Trends & Risk Assessment

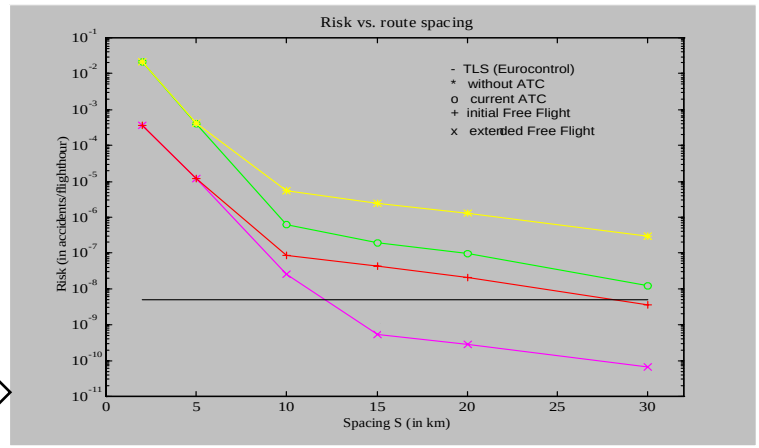
- **Precursor Assessment**
  - Incident Data Monitoring & Modeling
  - Human-Causal Analysis
- **Error Identification & Prediction**
  - Error Modes & Contexts
  - Design Induced Error
- **Propagation**
  - Simulation &
- **Risk Determination**

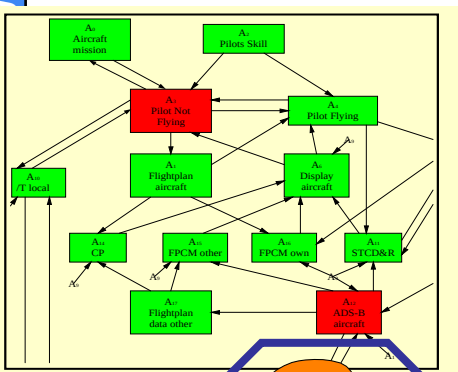


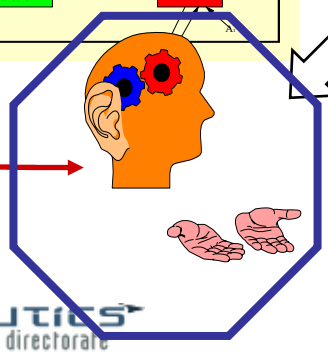


TOPAZ –MIDAS
Human Performance Link

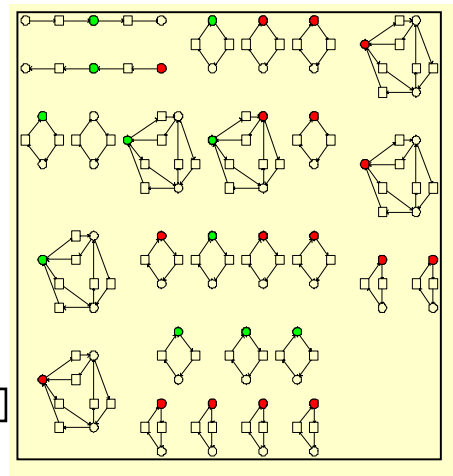




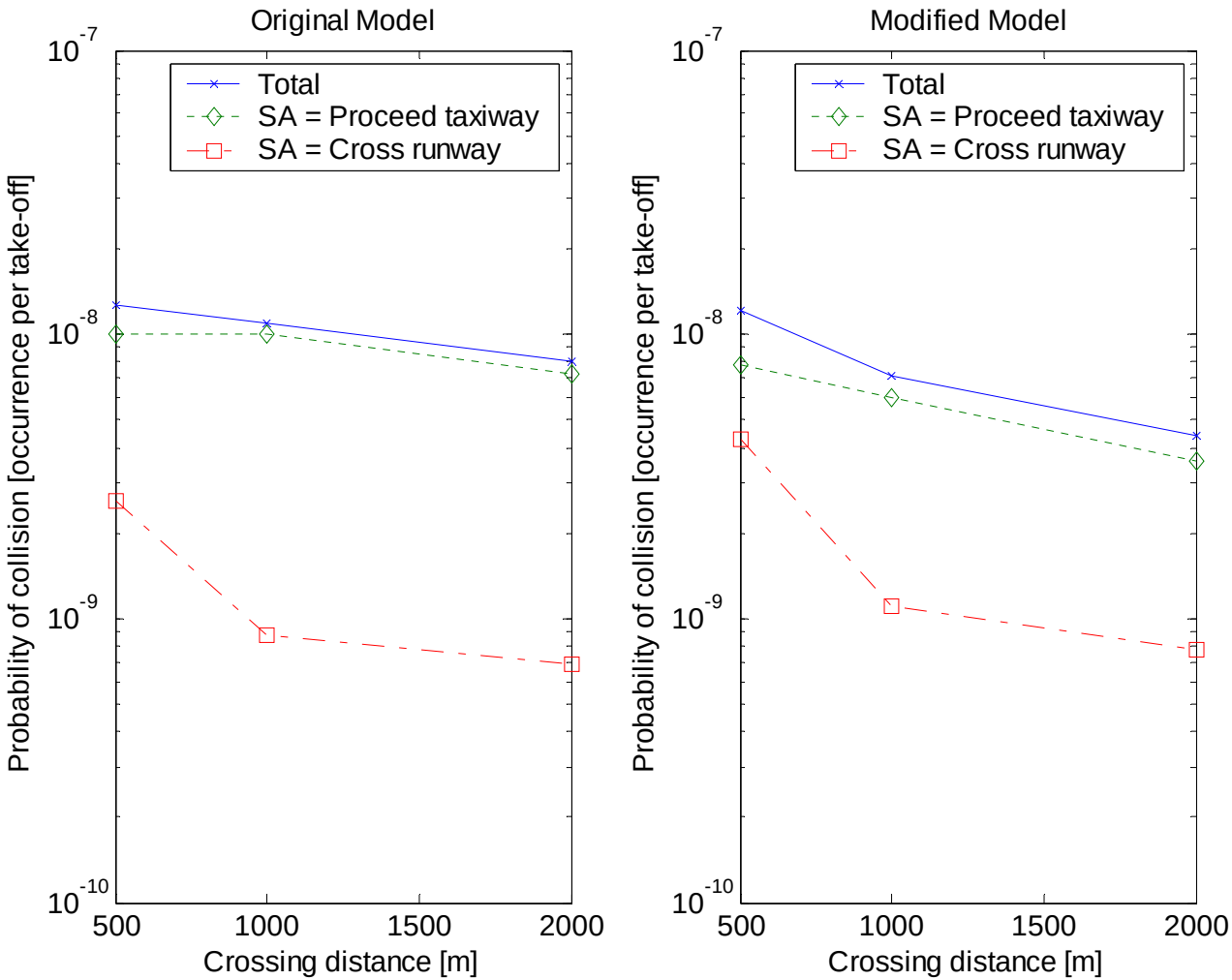




$$\Re_{[0,T_H]} = \frac{1}{2}\sum_i \sum_{j\neq i} \sum_l \int_0^{T_H} \varphi^{ij}\left(t \middle| \kappa_{t_*}^{ij} = \kappa^l\right) dt \cdot P\left\{\kappa_{t_*}^{ij} = \kappa^l\right\}$$

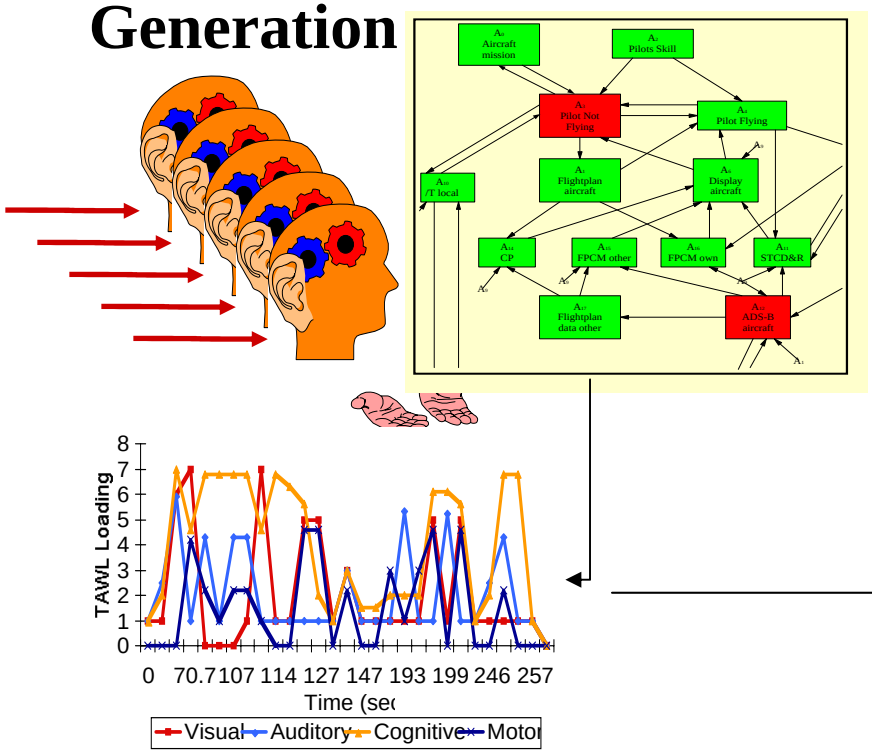


TOPAZ-Air MIDAS Integrated Operation



Human Performance & Risk Assessment

Phase 1: Parameter Generation



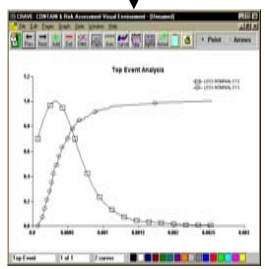
Run full HPM in 5 parallel scenarios to generate critical performance parameters

(> 100 runs)

Run parameterized reduced HPM model integrated into RFS

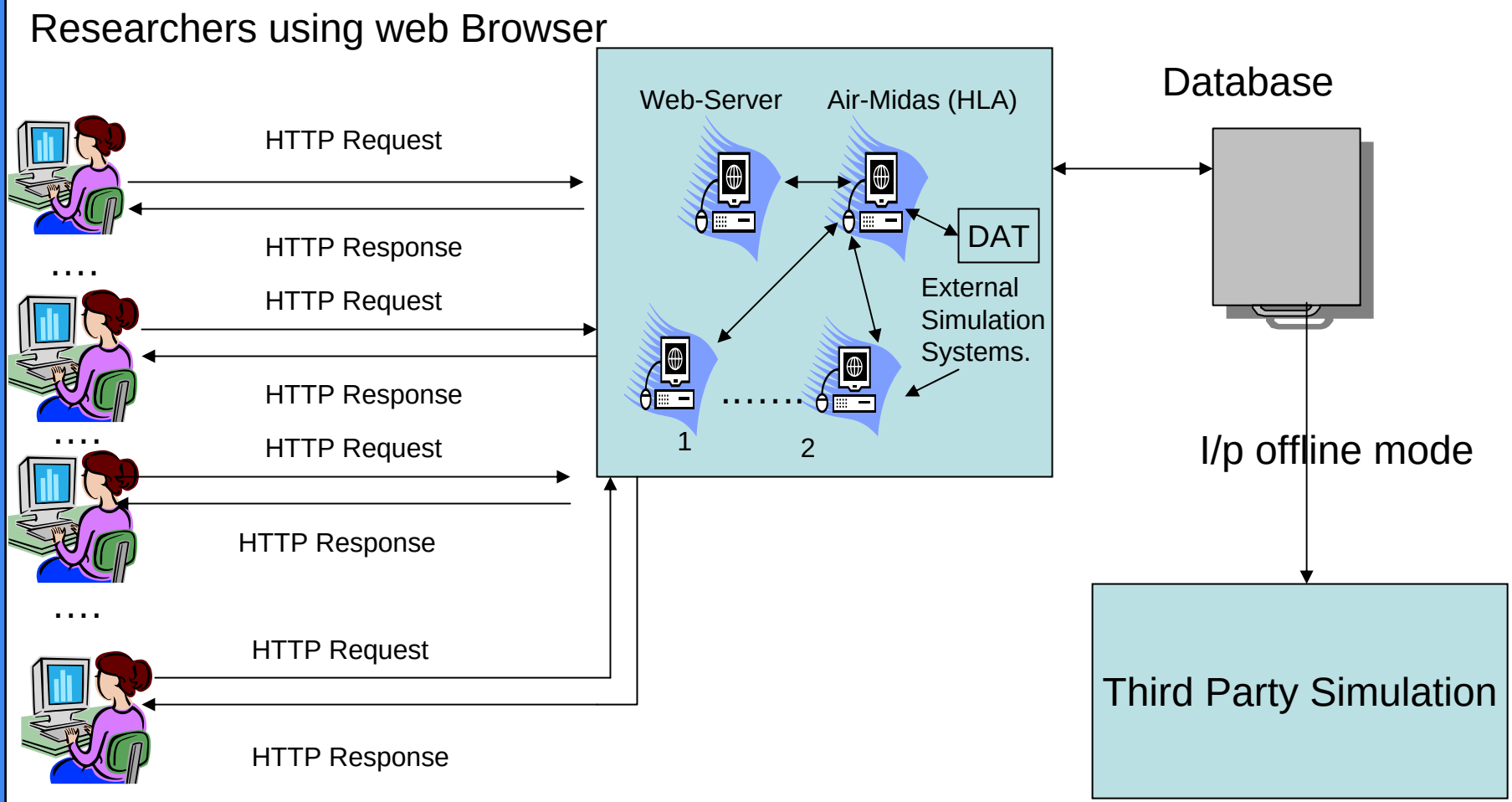
(>1,000,000runs)

Establish Hazard Levels Based on Rare Event Identification



Phase 2: Risk Determination

Web Based HLA Compliant Distributed Air-Midas Architecture



Short-list: Questions to be answered in research

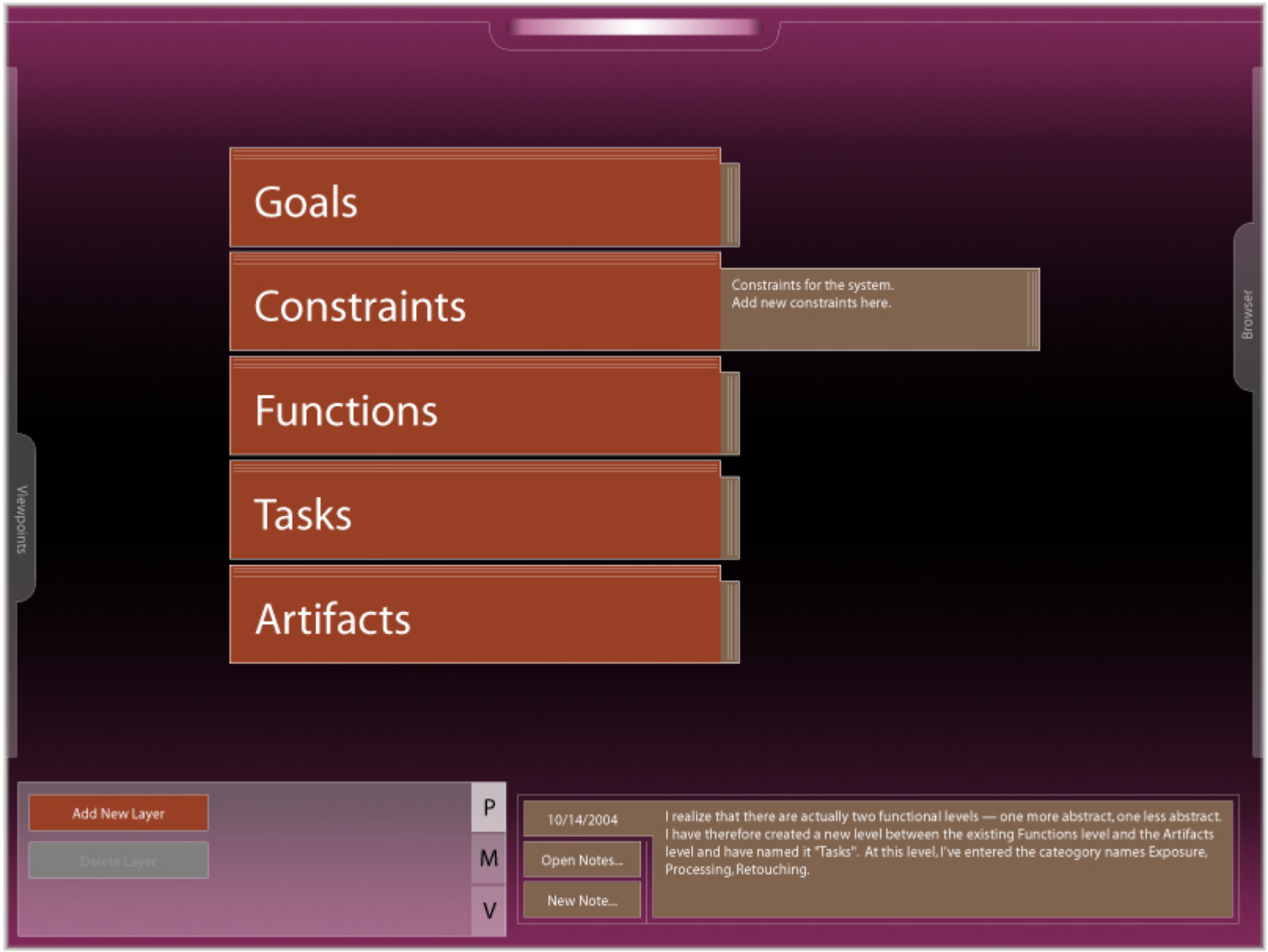
- **Who needs to know what, when and under what operating conditions?**
- **What are the informational issues associated with cooperative problem solving and distributed decision-making?**
- **What is the relationship between information and responsibility?**
- **How do tools (available or new) feed into the information/responsibility issues?**
- **What are the perceptions (misperceptions) of responsibility, how are then supported?**
- **How are workload (tasks) distributed, over people and over time?**

Short-list:
Questions to be answered in research

- **Are pilots and controllers cognitively and personally predisposed for their new way of working?**
- **Has the selection criteria for past systems provided the right skill mix for new systems?**
- **How is the system handled in off-nominal situations?**
- **Where are the transitions among system operating states and how are hand-offs normally accomplished?**
- **What are the issues associated with cooperation (of lack of) among ATM constituents**
- **Is there a general perception of fairness? If not, what behaviors ensue?**

Information Access Cognitive Systems

- **Operational Concepts & Developments**
  - Goals
  - Constraints
  - Functions
  - Tasks
  - Infrastructure & Equipment
- **Accessible from multiple perspectives**
  - Scenario design
  - Experimental methodology applications
  - Baseline data from prior experiments
  - Procedure analysis
  - Design guidelines
  - Illustrations
  - Risk Assessment Tools


Goals
Constraints
Constraints for the system.
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10/14/2004
Open Notes...
New Note...
I realize that there are actually two functional levels — one more abstract, one less abstract. I have therefore created a new level between the existing Functions level and the Artifacts level and have named it "Tasks". At this level, I've entered the cateogory names Exposure, Processing, Retouching.


Constraints
Sensitometry
At a glance...
Goals
Constraints
Functions
Tasks
Artifacts
Sensitometry has to do with light mechanics. It's a larger topic, more abstract in nature and therefore can also be useful as a constraint.
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Sensitometry
Dodging
Dodging and burning certain areas- lightening or darkening portions of the image, respectively—are perhaps the most basic, and most used, of all darkroom procedures.
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Dodging and burning certain areas- lightening or darkening portions of the image, respectively—are perhaps the most basic, and most used, of all darkroom procedures.
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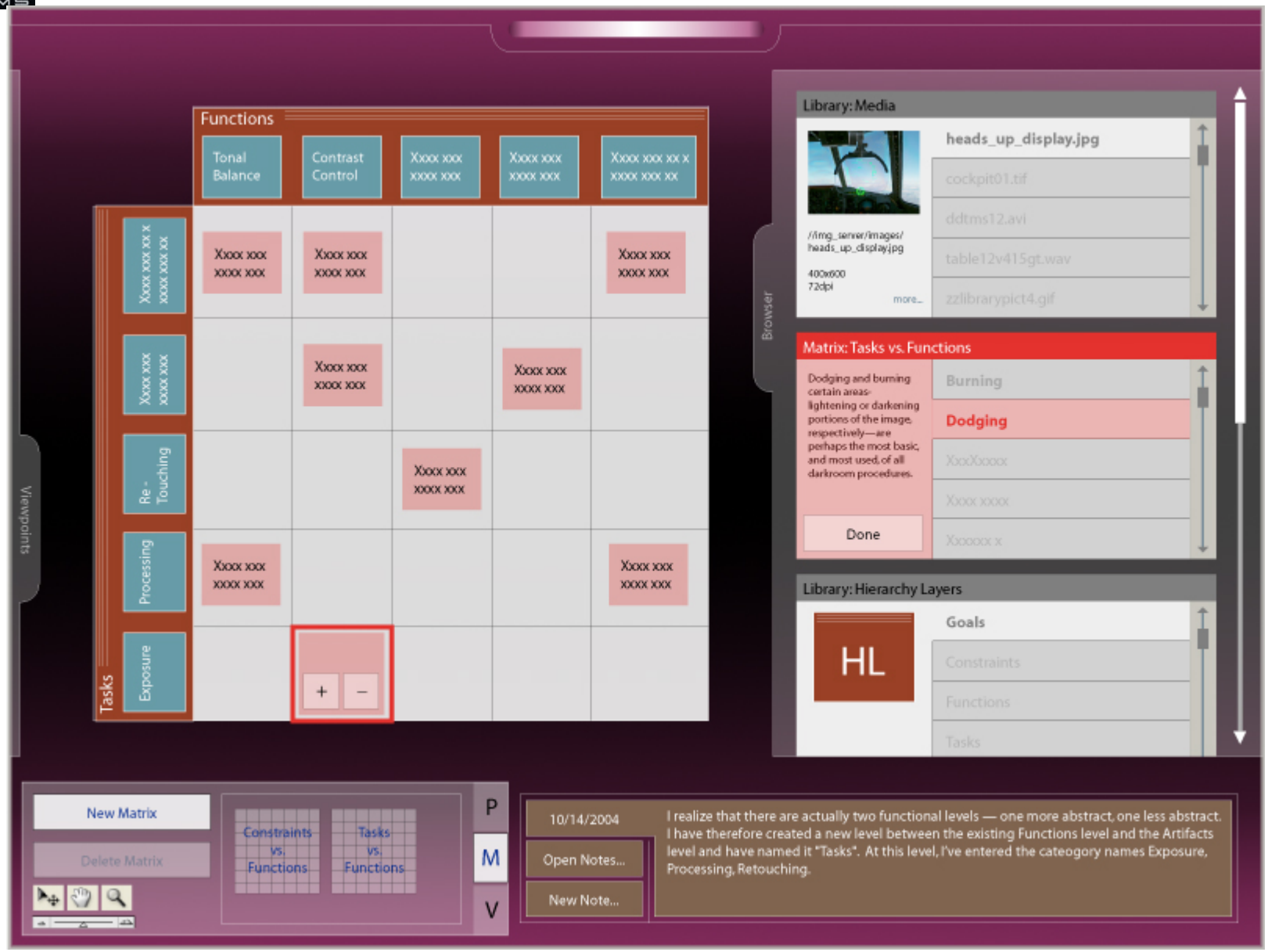
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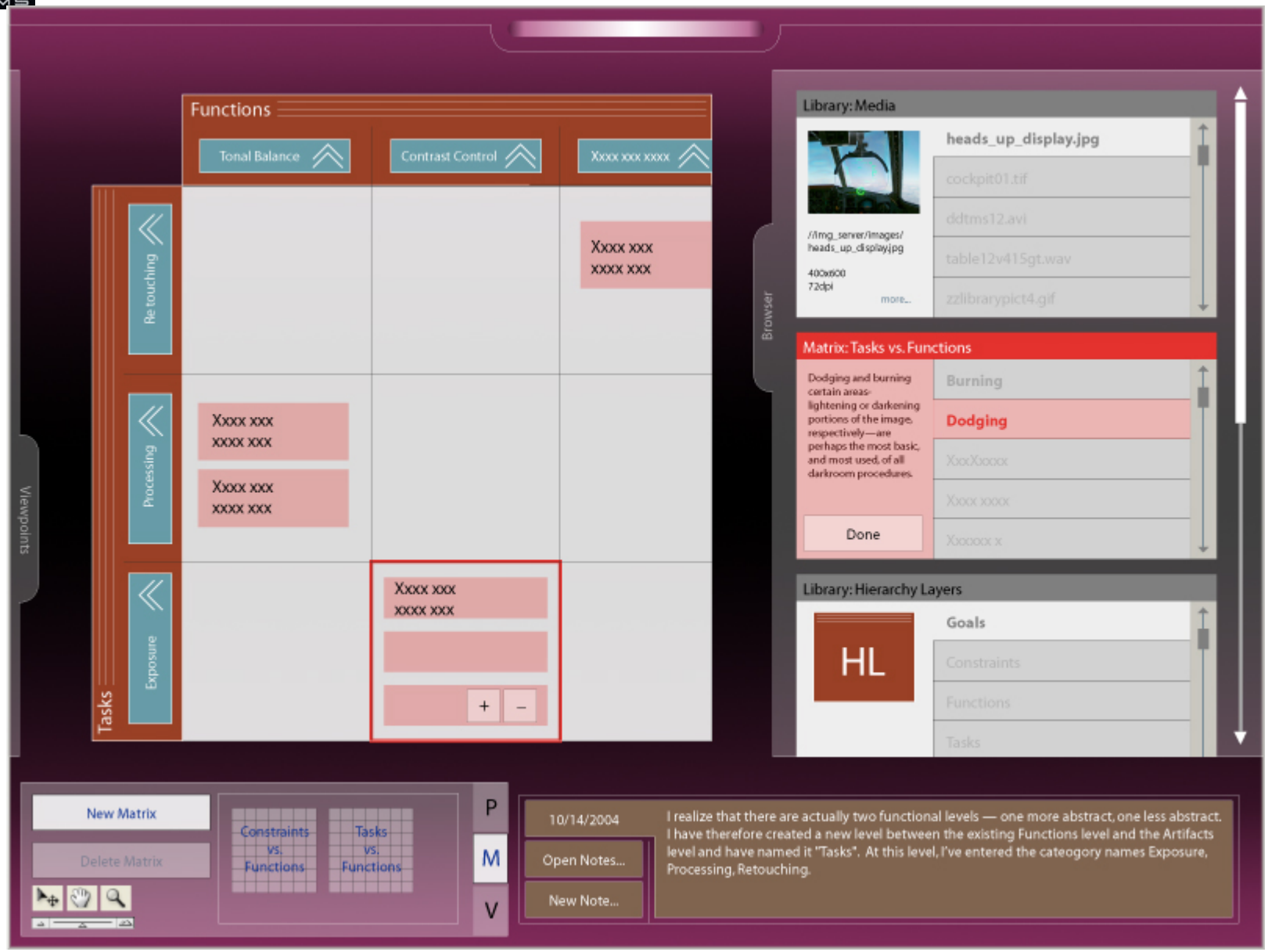
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Summary TOOLKIT Approach

- **We know a great deal about human-system integration with respect to the aforementioned questions.**
  - Accessible and Usable Data Repository (with links to international data repositories (VDR)).
- **Some questions require focused answers. How to provide them?**
  - Develop a human human-system micro-model set for point simulation
  - Use current simulation components and data fro immediate answers
- **All system changes have propagated effect. How to assess?**
  - Experimental focus on seams, ambiguity, etc.
  - Field studies linked to both knowledge base and simulation systems